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Photogrammetry - Automating the Collection of Shipcheck Data

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Photogrammetry - Automating the Collection of Shipcheck Data

VIIB-1

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ABSTRACT

The installation of new or modified systems on board U.S. Naval combatants during overhauls requires advance planning shipchecks. One primary purpose of a shipcheck is to document existing shipboard conditions in order to develop engineering drawings for the installation of these new systems. Gathering and documenting existing shipboard conditions has always been a very labor intensive effort. Also, accuracy of measurements is restricted by congested spaces, dimensions of extensive length, and intricate configurations of systems. Furthermore, the accuracy of the shipcheck information relates directly to the quality of the production installation. Accurate well-planned ship check information will reduce production interferences, production costs and schedule variance. One objective of a planning department is to reduce manday expenditures required to accomplish a ship check while increasing the accuracy of the data gathered. Automating this ship check using photogrammetry, specifically stereo photogrammetry, can provide a means to achieve these objectives. This paper will explore the use of stereo photogrammetry to gather ship check data for shipboard distributive systems such as piping, ventilation, cable ways, compartment arrangements and structural components.

BACKGROUND

What follows is a description of how a typical advance planning ship check is accomplished. First, the task is identified. This typically may require the removal or modification of existing systems and the installation of new mechanical or electrical systems. Structurally it may require the removal, penetration or modification of existing structures or installation of new structures to accomodate these new or modified mechanical or electrical systems.

The decisions to modify existing systems or install new systems are made by shipyard engineers and technicians responsible for each system. Existing conditions are examined and evaluated and decisions formulated on how the task will be accomplished. Each technical code or discipline is then required to gather the necessary data in order to accomplish their portion of the entire task.

Generally, personnel from all engineering disciplines (structural, mechanical, and electrical) will ship check the same compartments to obtain needed information to complete their individual drawings. This leads to duplication of effort as well as added opportunity for error in measurements with several people locating points of interest from different vantage points.

Following is an example of where error in measurements and duplication of effort can enter into the process. A mechnanical engineer may locate a new piece of equipment off a bulkhead, deck, or structural stiffener. An electrical engineer may have to locate power boxes in this compartment to provide power to this new piece of equipment, while the structural engineer is required to provide a foundation. All three will need to sketch the existing structure. With the breakdown of several systems over many technical groups it becomes readily apparent that many people will be duplicating measurement efforts even in this simple example. This process also allows for unavoidable measurement errors. As an example (figure1), dimensions of an existing transverse beam can be taken from a

forward bulkhead by one person and an aft bulkhead by another. Since both bulkheads are located on a frame, both dimensions taken should give the same location of the beam. However, these bulkheads, for one reason or another, are typically not exactly on frame. Errors during installation, by excessive loading, or deformation from damage are but a few reasons for these misalignments.

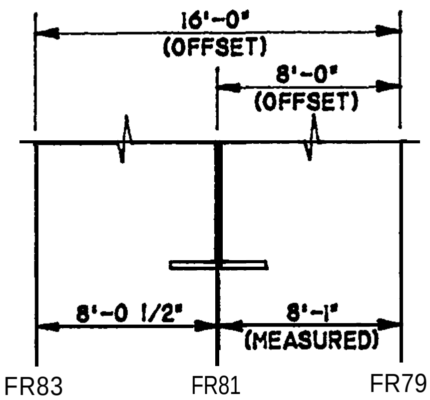

FIGURE 1.

DISCUSSION

Ship checking with photogrammetry can be accomplished with either or both of the two methods used in photogrammetry, convergent or stereo. Convergent is generally more accurate, but requires all points of interest to be targeted prior to photography. Stereo is generally more versatile in ship checking applications since data points are gathered in the office from stereo pairs (overlapping photos) which produce a **"3D"** picture for data extraction. Other situations where stereo is the method of choice over convergent include the inability to physically place targets, large degree of congestion when determining camera vantage points, and excessive number of data points required to define an object.

Photogrammetry can be used effectively in ship checking to resolve some of the short comings of conventional ship checking. First, data points that are captured can only be at one coordinate point, whether the coordinate system is local or in the ship's coordinate system. Not only are measurement errors eliminated, but the actual dimensions themselves are more accurate. Secondly, photogrammetric data points that are input in a CAD unit for reconstruction allow the "ship check" to be performed in the office. "Ship checkers" are not affected by environmental factors such as hot or cold weather, movement of ship, rotating equipment or environmental hazards such as radiation. Also, unavailability of key personnel being able to travel to remote sites for long periods of time can be overcome. The inexperience of a ship checker can be virutally eliminated as a contributing factor to ineffective ship checking. Finally, with the use of stereo photogrammetry any change in guidance occurring after completion of shipcheck can be overcome. For example, a change in equipment vendor could result in a larger unit being installed, thus requiring additional systems to be relocated or modified. Stereo pair photographs can be reused to extract additional information that may be required at a later date. With conventional shipchecking methods, a revisit to the ship is almost always required.

PLANNING

An example of shipchecking with photogrammetry is a recent project on the USS CONSTELLATION (CV64). The area selected for the photogrammetric survey was Pump Room #**5** '(7-195-0-E) which contains fuel oil and fire pumps, air conditioning plants and the associated distributive piping systems. This compartment also contained a false floor or grating which limited accessibility to the areas being surveyed (figure 2).

As built installation drawings and ship alteration drawings for the pump room were reviewed. Various piping systems, Ventilation systems, equipment and structures were selected for the photogrammetric survey. The criteria for selecting systems to shipcheck consisted of areas that were congested with limited accessibility, systems with complicated arrangements that would be hard to shipcheck manually, and systems from varing disciplines to determine if any pose unique difficulties or peculiarities. With the use of stereo photogrammetry it was not necessary to decide on specific data points during the site preparation and photo phase, rather it was only necessary to decide on which systems or groups of systems were required to be picked up in order to plan the camera stations (points from where photos would be taken).

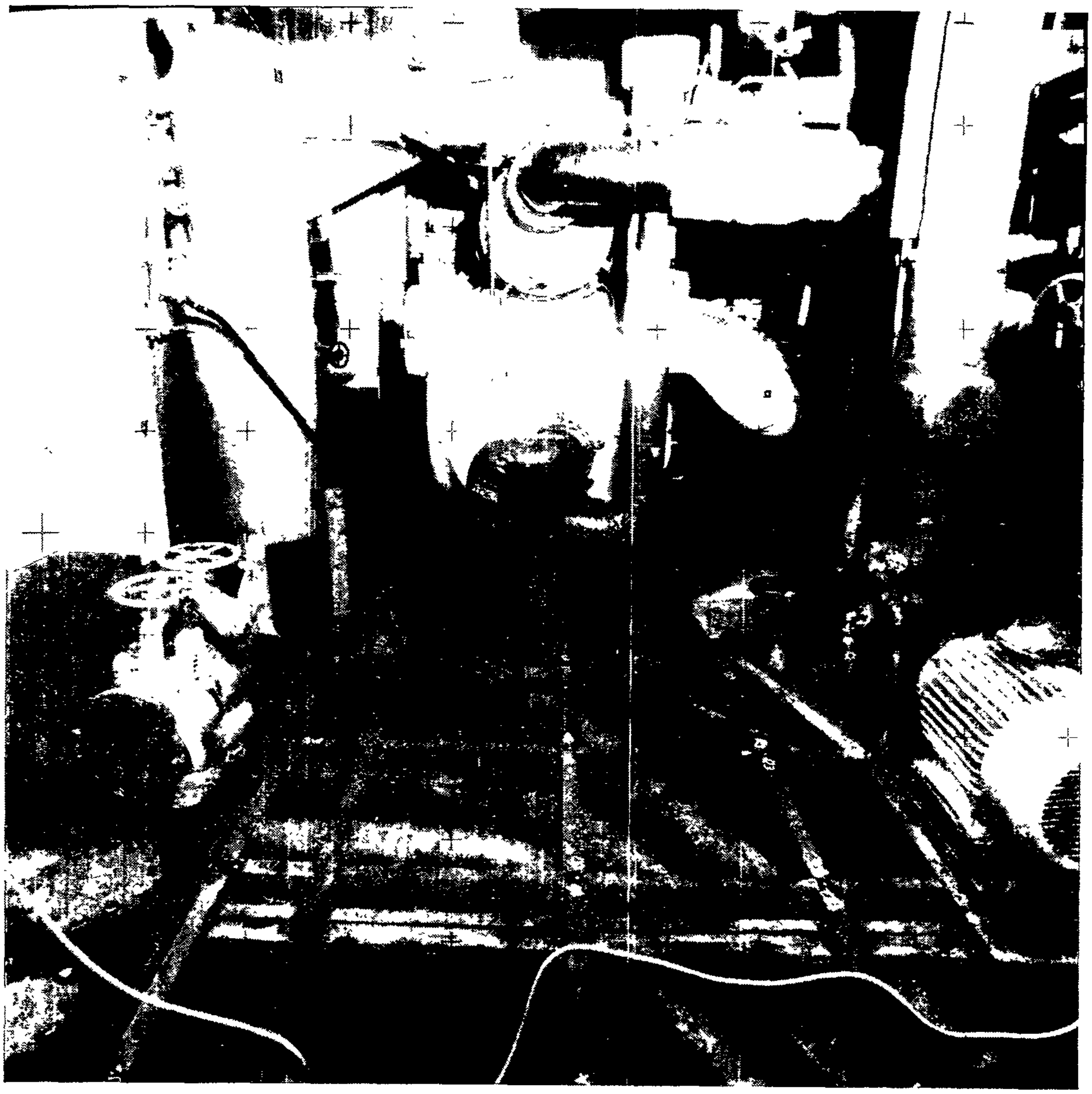

FIGURE 2. PUMP ROOM #5

Convergent photogrammetry was used to set up a coordinate system in relationship to the bulkheads that made up the boundaries of the compartments and to tie the photos together into a network. In this case the bounding angles that remained after deck plates were removed provided locations for the convergent targets to be placed.

As with any photogrammetric project the planning included determination of camera and film medium (controlled for the most part by accuracy levels required), amount of lighting required across the full spectrum of the photograph to allow for sufficient exposure to read the negatives, proper highlighting to provide enough contrast to identify data points and location, and frequency of photos to ensure sufficient coverage.

A semi-metric Rolleiflex 6006 camera employing 70mm Kodak Plus-X Ester-base film was chosen due to its ability to obtain data within our 1/8" accuracy requirements. Also, film as opposed to glass plates allows you to progress at a much faster rate.

With the preplanning completed? some of which was accomplished during the shipcheck, the site preparation could begin. This consisted of placing and numbering targets used in the convergent portion of this project, laying out camera stations and outlining foundation edges and lightening holes with paint to provide contrast. Photos were then taken and reviewed to ensure that both quality of photos and areas of interest were captured (figure 3). That essentially completed the photogrammetric portion of the shipcheck.

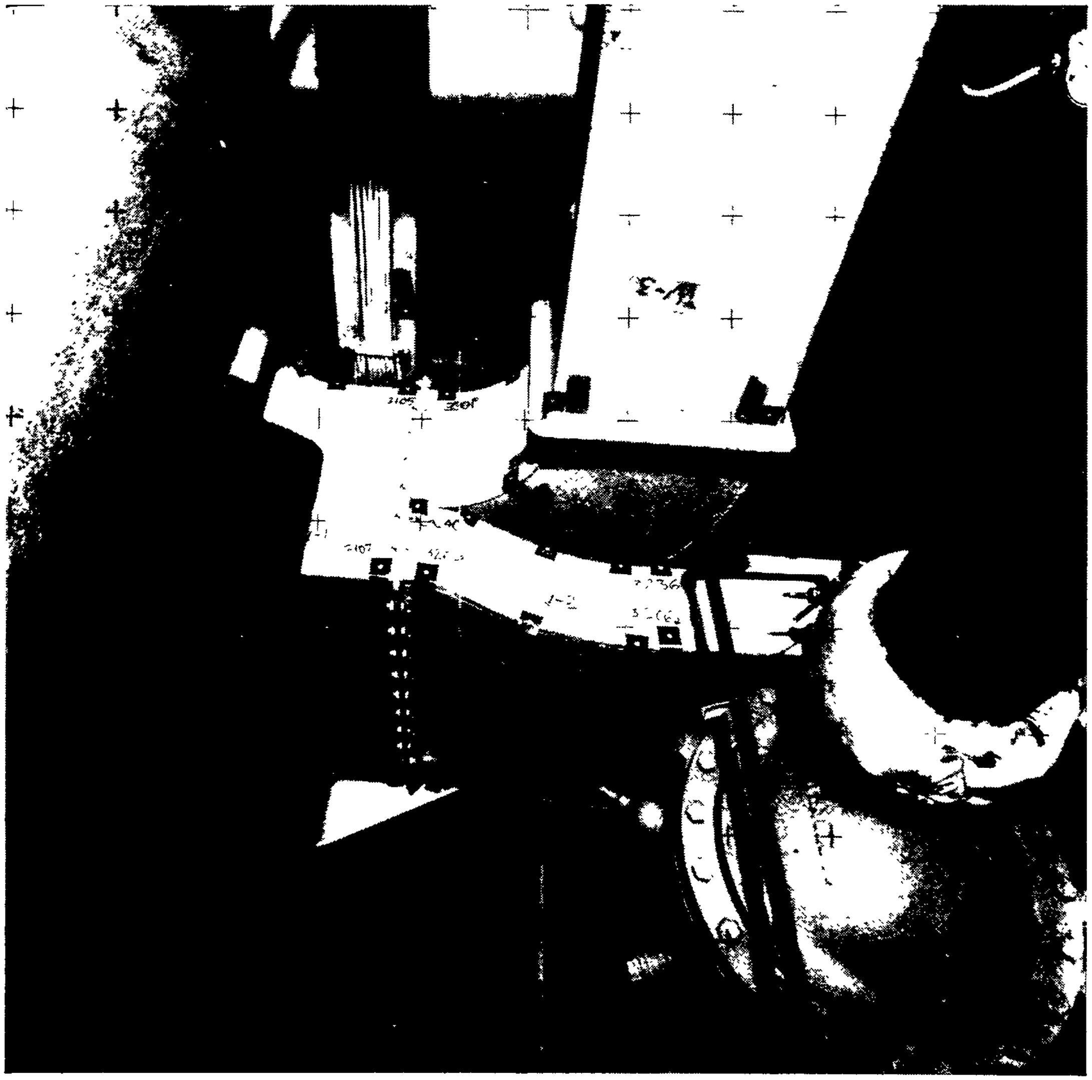

FIGURE 3. PUMP ROOM #5, OVERHEAD VENTILATION

In the office stereo photo pairs were placed in the analytical compiler and objects of interest such as piping systems were measured. The process of measuring photos and providing X,Y,Z coordinates is commonly referred to as data reduction. The analytical complier provides X,Y,Z dimensions. Three dimensional measurements of photographs requires an experienced photogrammetric technician to correctly measure the points.

One of the goals of this project was to take the coordinates generated from the photogrammetric survey and reconstruct CAD drawings. A computer tape of the X,Y,Z coordinates was loaded into a Computer Vision CAD system. This raw data was plotted as points in space (figure 4 and 5). The CAD operator used these points to develop detailed system drawings.

The photogrammetric pictures were also necessary, along with the plotted points for the CAD operator to develop these drawings. The pictures allowed the CAD operator to relate the data points to shipboard conditions. An area of CAD reconstruction that should be emphasized is the importance of the photogrammetric technician who is responsible for digitizing the X,Y,Z coordinates of the stereo pairs. If the photogrammetric technician is aware of the type of dimensions required by the CAD operator the data supplied may be sufficient to develop the CAD drawings. It appears however, that the CAD operator and the photogrammetric technician must have a close working relationship in order to process additional information as required.

The CAD operator must also provide the intelligence to the data points.

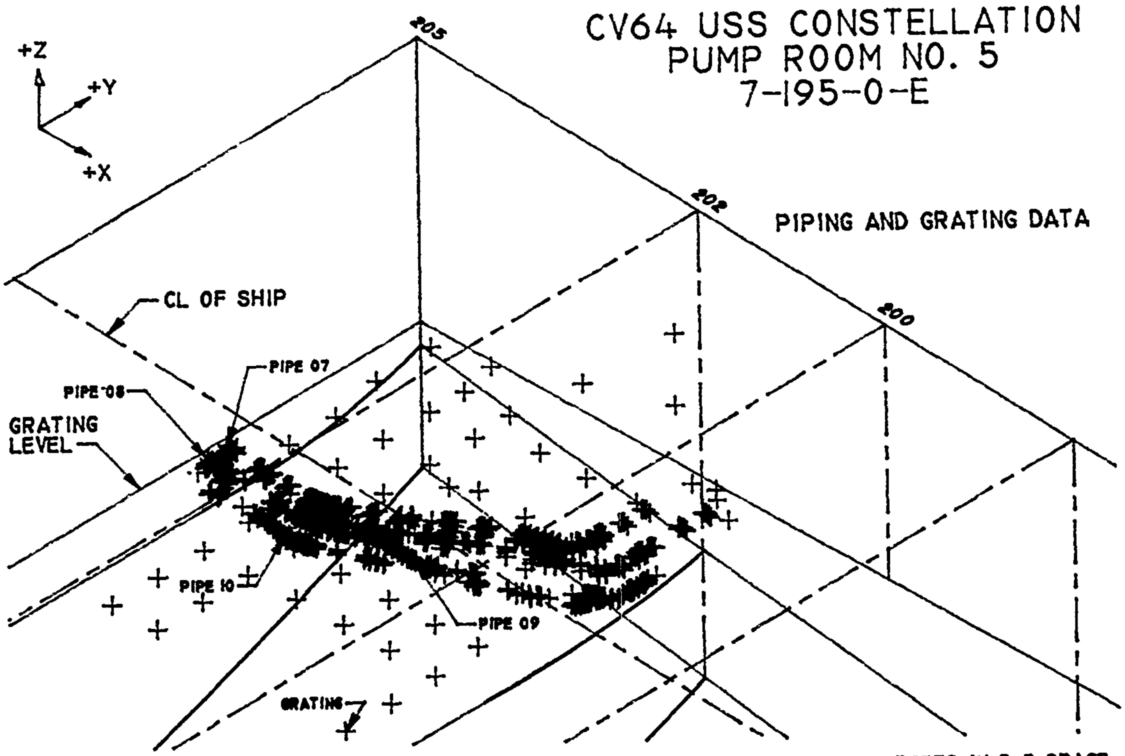

FIGURE 4. PLOTTED POINTS REPRESENT XYZ COORDINATES OF PHOTOGRAMMETRIC TARGETS IN 3-D SPACE

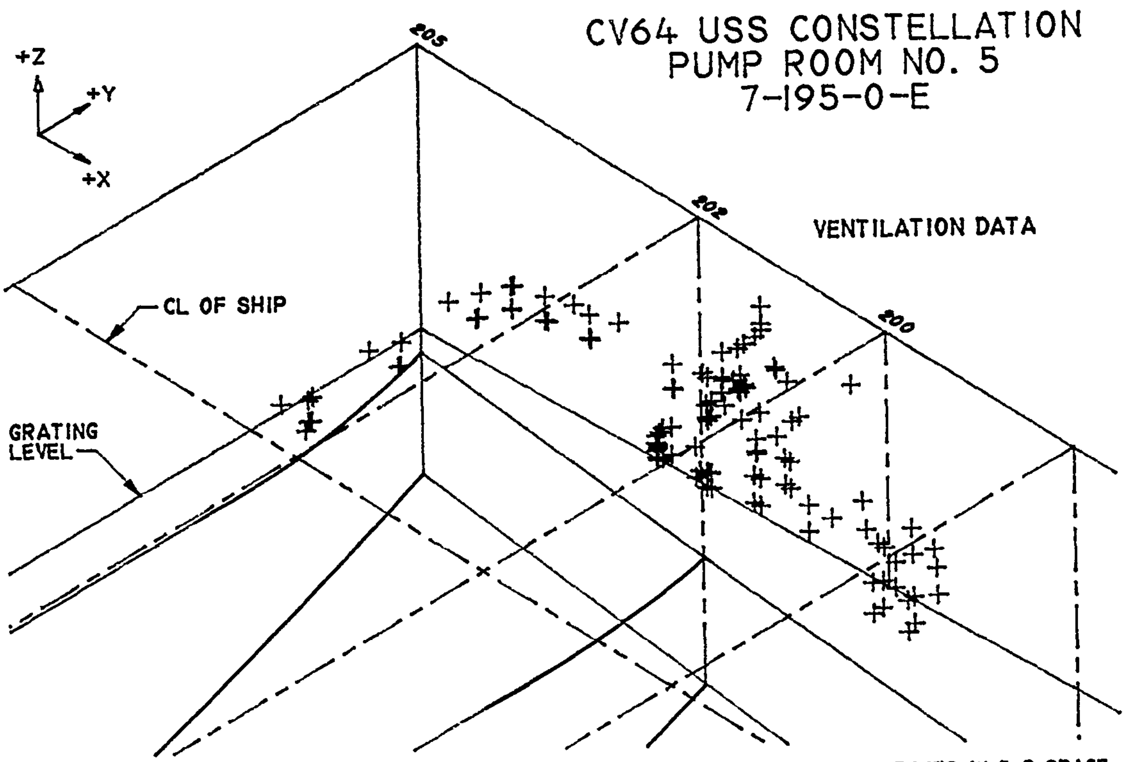

FIGURE 5. PLOTTED POINTS REPRESENT XYZ COORDINATES OF PHOTOGRAMMETRIC TARGETS IN 3-D SPACE

He or she must attach the characteristics/parameters to systems being constructed such as material, wall thickness, size etc. The point to be emphasized is that photogrammetry is not a turn key operation to drawing development. The reconstruction of photogrammetric information into CAD drawings requires skilled CAD operators and time. Photogrammetry provides accurate locations that document existing conditions, the CAD operator creates the engineering drawing (figure 6-8).

RESULTS

The aspects of this project that were critiqued are the ability of the equipment to capture the data, the accuracy of the data gathered and cost comparisons of a conventional shipcheck versus a photogrammetric shipcheck.

The areas chosen to be surveyed *were* selected because of the difficulty they would have presented if shipchecked manually. As mentioned earlier, the systems surveyed contained complex geometries or were located in hard to access areas. None of these situations proved difficult for gathering photogrammetric data.

It should be noted that this area was previously shipchecked manually to support an upcoming overhaul. This allowed us to compare results of the survey to a manual shipcheck. The table below compares manually measured shipcheck information versus photogrammetric data for two piping runs. The measurements shown are at the bulkhead penetrations (Table I).

An acceptable level of accuracy for a manual shipcheck is 12.7 mm **(.5")**. This is an arbitrary number chosen mainly from past shipcheck experience. A comparison of the differences between photogrammetric data and manual shipcheck data, given the allowable accuracy of the manual measurement, demonstrates favorable results.

One of the biggest problems of a manual shipcheck is missing

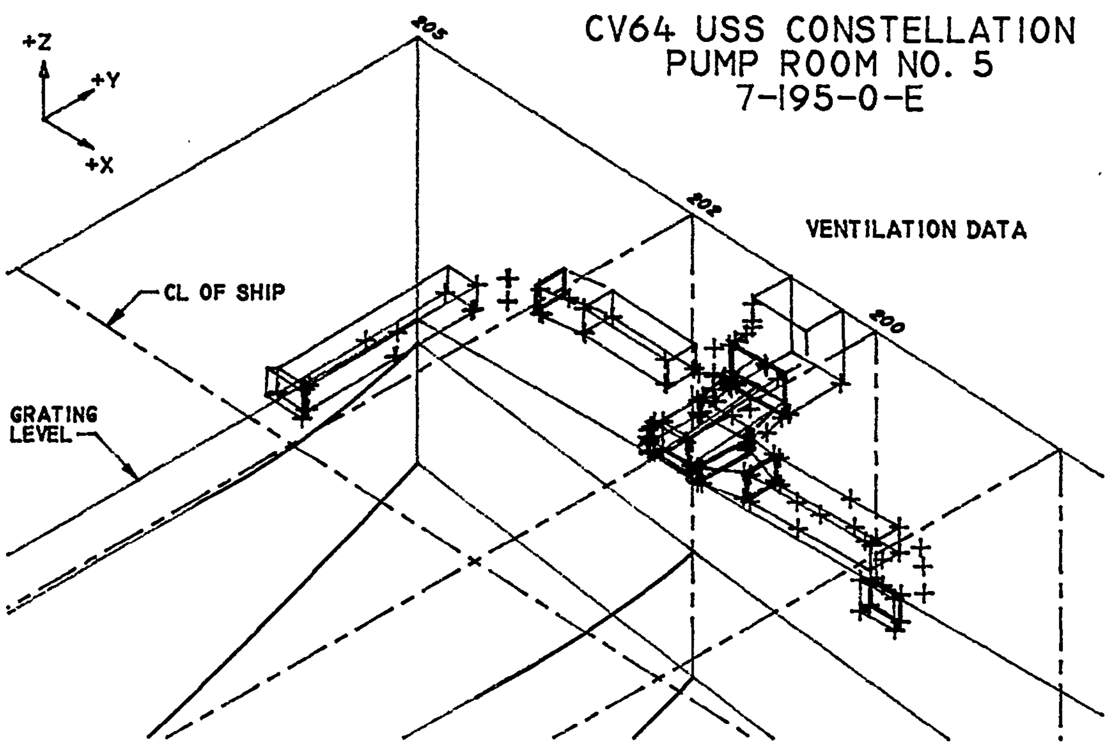

FIGURE 6. LINES FROM POINT TO POINT TO RECONSTRUCT VENT IN 3-D MODEL

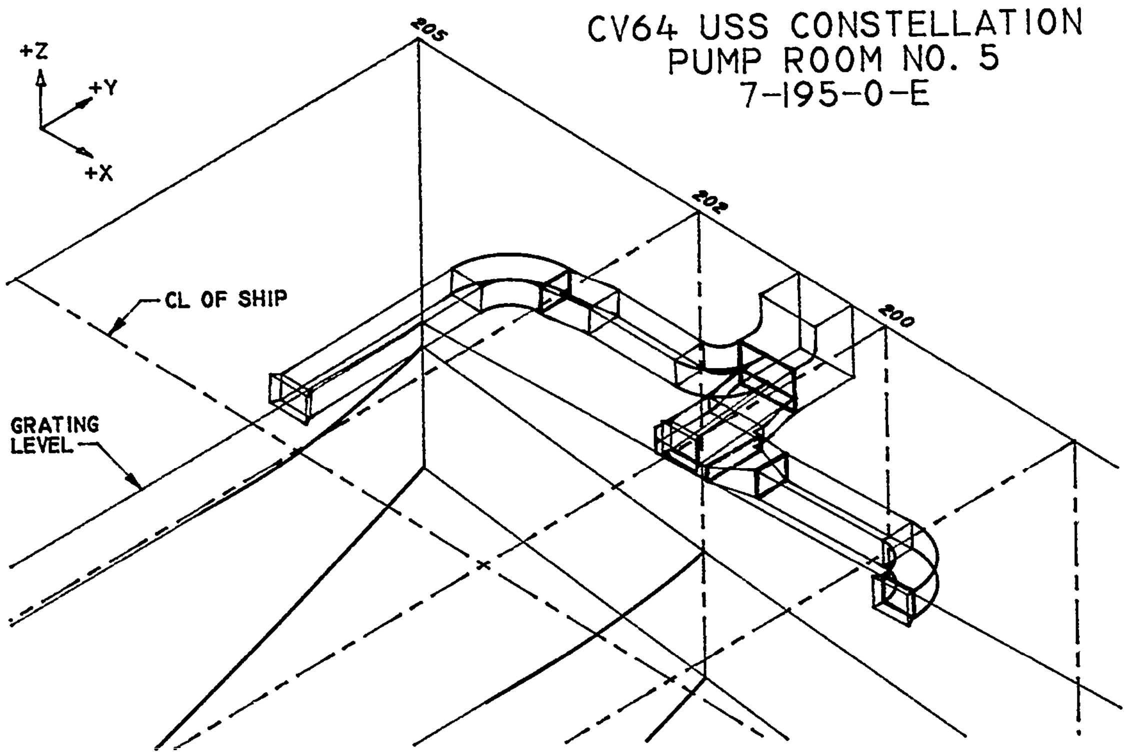

FIGURE 7. 3-D CADD MODEL RECONSTRUCTION OF VENT FROM PHOTOGRAMMETRIC DATA

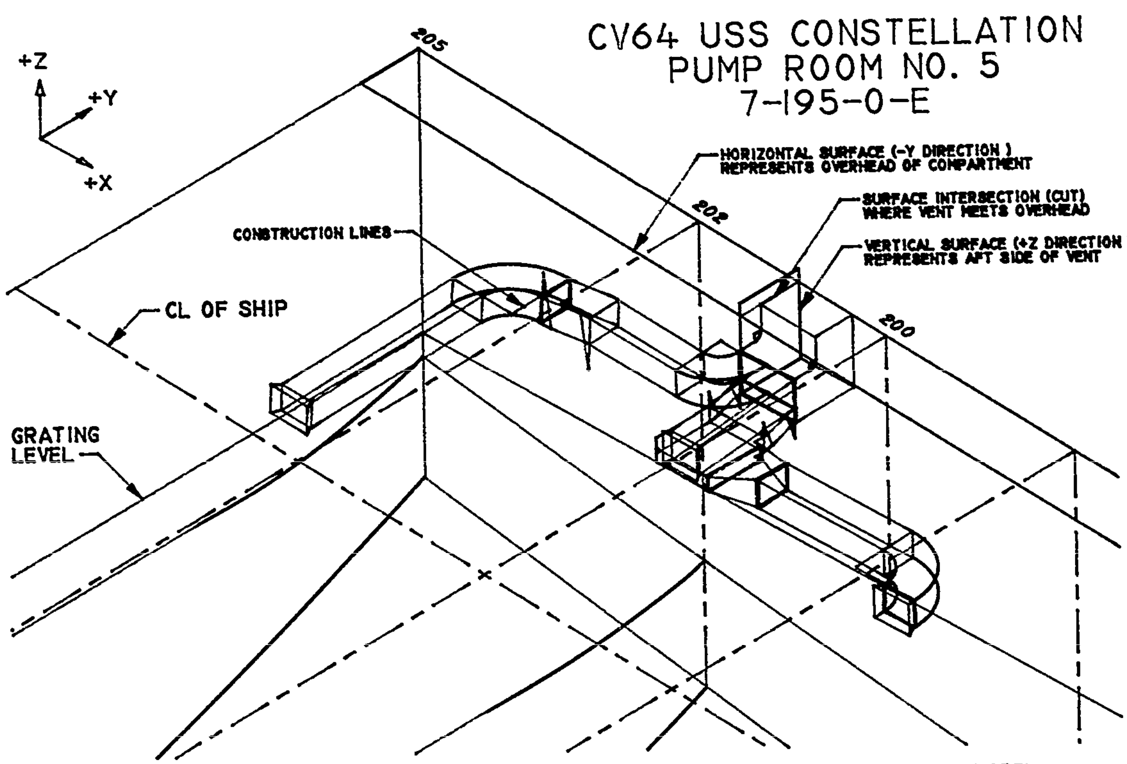

FIGURE 8. SURFACES AND CONSTRUCTION LINES USED TO RECONSTRUCT VENT IN 3-D MODEL

TABLE 1, DATA COMPARISONS

PIPE	PHOTOGRAMMETRIC	MANUAL	DELTA	MAN s/c ACCURACY
	DIST. FROM ,BHD 205			
P-8	3879.85MM (l52.75IN)	3881.12 (152.8)	l.27 (.05)	+12.7 (.5)
P-10	3949.85MM (l55.5IN)	3961.13 (l55.95)	ll.43 (.45)	
	DIST. FROM LONG. BHD			
p-8	2856.18MM (ll2.45IN)	2857.5 (112.5)	1.32 (.052)	
P-10	2831.6MM (lll.48IN)	2838.45 (111.75)	6.86 (.27)	

information or oversights by shipcheck personnel. Besides accuracy, the other advantages of a photogrammetric survey is the ability to retrieve additional data at a later date. For example, with the use of photogrammetric shipcheck data, a location of a fitting that was omitted from the survey data can be requested by the CAD operator at any time. This one benefit alone is invaluable in increasing the quality of engineering prints.

The cost comparisons of manual shipchecks and photogrammetric shipchecks are projected to be equal. Although the number of personnel needed to actually gather the information on site can be reduced, this is offset by the additional cost of reducing the data from the stereo pairs.

CONCLUSIONS

First and foremost, this project has proven that photogrammetry can gather shipcheck data for distributive shipboard systems. The data is also accurate compared to conventional methods of shipchecking. An intangible benefit that can not be overlooked is the ability to retrieve additional data at a later date. This project also demonstrated the flexibility of the equipment to shipcheck in congested areas and, as mentioned above, the cost of shipchecking using photogrammetry is comparable to conventional shipchecks. This is the first step in automating the shipcheck process.

Future efforts will be directed at refining procedures, such as expanding the survey to include multiple compartments, and investigating the techniques required to "tie in" all the data into one package. Another area being investigated is the proper applications of this technology. Are there certain shipcheck projects that lend themselves to stereo photogrammetry more than others? The goal of future research will be to refine the procedures to the extent that photogrammetry can become a routine shipcheck tool to be applied to high risk and complex shipchecks.

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